Journal of the Royal Society of Western Australia, 84: 29-32, 2001

Invertebrate occurrence and succession after episodic flooding of a central Australian rock-hole

I A E Bayly

Department of Biological Sciences, Monash University, Clayton VIC 3168*
*Address for correspondence: 501 Killiecrankie Road, Flinders Island TAS 7255
iaebayly@bigpond.com.au

Manuscript received June 2000; accepted August 2000

Abstract

A small rock-hole, located near Australia's point of inaccessibility, was sampled 10 times between its flooding on 20-21 April, 1998, and 16 June, 1998, when little water remained. Nine species were collected. Notable in occurrence was *Streptocephalus* (Crustacea: Anostraca) – a taxon long believed not to occur in Australia. New species of *Ilyocypris* (Crustacea: Ostracoda) and *Dorylaimus* (Nematoda: Dorylaimida) were discovered. The composition of the species assemblage differed markedly from that recorded from the relatively well studied granite gnammas in south-western Australia.

Keywords: rock hole, gnamma, flooding, crustaceans, central Australia

Introduction

Rock-holes capable of holding water are widely distributed throughout the arid regions of Australia. Despite the often cryptic and ephemeral nature of rock-hole waters, they have been of key importance for the survival of indigenous people in desert regions for thousands of years (Bayly 1999a). Studies of aquatic invertebrates associated with Australian rock-holes have been largely neglected until recently (Bayly 1997). Bishop (1974) studied a series of shallow pools in sandstone at North Head, Sydney, and Kanangra Walls, Blue Mountains, and recorded 18 taxa of invertebrates. Bayly (1982, 1997) studied the invertebrates of 55 gnammas on granite outcrops in southern Western Australia and found just over 100 invertebrate taxa including about 10 new species.

In central Australia, some invertebrates collected from quasi-permanent waters in large rock-holes (not gnammas) associated with gaps or gorges in the Macdonnell Ranges have been studied and identified. For example, Bayly (1964) recorded *Boeckella triarticulata* (Copepoda: Calanoida) from Simpson's Gap, Hugh Gorge and Glen Helen Gorge. However, the invertebrates living in temporary waters in the small rock-holes of central Australia have hitherto been neglected. The aim of this paper is to make a contribution to the filling of this gap.

Study site

The study site (Fig 1) was a rock-hole on Warumpi Hill situated about 4 km east of the Northern Territory community of Papunya (23°15' S,131°54' E), and only about 50 km from Australia's point of (mean maximum) inaccessibility from the coastline which is just south of Lake Lewis. The rock-hole (Fig 2) was located near the middle of a bare patch of rock positioned about three-quarters of the distance up the northern face of the highest portion of the hill. The summit has an altitude of 738 m above sea level and stands 120 m above the surrounding plain. Rock samples taken from the immediate vicinity of the rock-hole consisted of granitic gneiss of Lower Proterozoic age.

In plan, the rock-hole is shaped like an irregular biconvex lens with a maximum length of 225 cm and a maximum width of 43 cm. The maximum depth was 90 cm and the maximum volume of the rock-hole was about 400-500 L. From each of the two pointed extremities on either side of the lens-shaped rock-hole, a line or fracture-trace, indicating a joint plane, extended outwards on the surface of the rock for a distance of 2-3 m. This rock-hole, though not corresponding exactly, may be compared with the landform described as a "canoe" by Twidale & Corbin (1963). This form is sometimes referred to as a "water-eye"

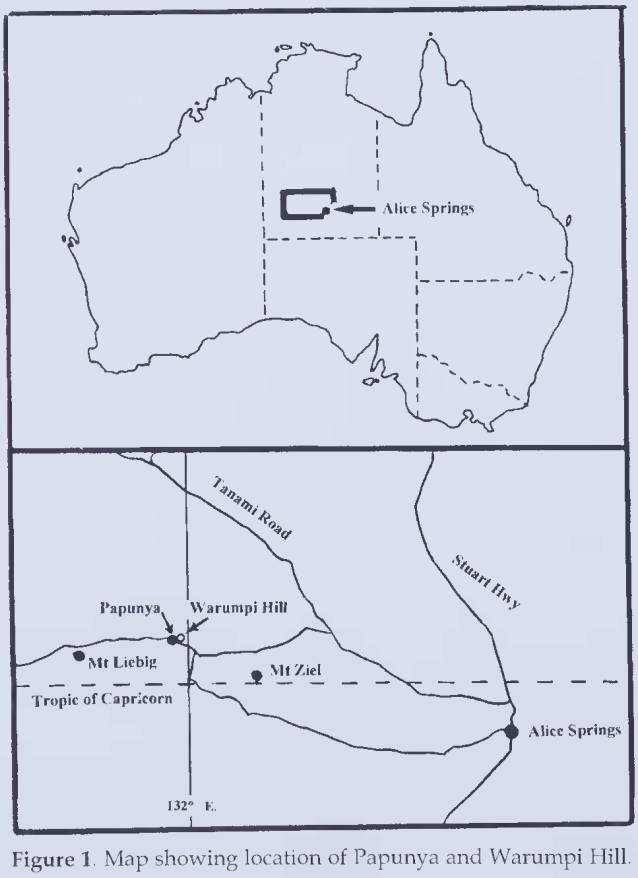

Figure 1. Map showing location of Papunya and Warumpi Hill.

Figure 2. The rock-hole, located in granitic gneiss, appears as a dark lens-shaped object in the central foreground. The hilltop in the distance is a secondary eminence rather than the highest point of Warumpi Hill; the direction of the true summit is to the left and approximately at right angles to the central line of sight (roughly west) of the photograph.

because of its lenticular or half-eye appearance in plan. The Warumpi Hill rock-hole thus differs significantly from the more common gnammas described and figured by Bayly (1999b).

The rock-hole was first observed on 24 March, 1998, when it held a small amount of water (depth *ca* 10 cm) in the bottom. This water was probably the remains of a flooding produced by the 38 mm of rain that fell 45 days earlier on 7 February. Between 24 March and 20 April, only 5 mm of rain was registered at Papunya and the mean daily maximum temperature was 32 °C. It may therefore be assumed that no free water remained in the rock-hole immediately before the deluge that occurred on 20-21 April, 1998. Heavy rain commenced in the evening of 20 April and 53 mm had been registered at Papunya by 07:45h on 21 April. It was this episode that provided the opportunity for this study.

Methods

The Warumpi Hill rock-hole was first sampled on the afternoon of 26 April, 1998, or almost six days after the start of the downpour. During the next seven weeks a further nine samples were taken at intervals ranging from 3-9 days and averaging 6 days (Table 1). Sampling ceased on 16 June when a small amount of water was still present (there was no significant rainfall between 21 April and 16 June.) The rock-hole was re-inspected on 19 July when no free water was left, but damp mud was found on the bottom. A 500 ml sample of this mud was collected and was used by Nicholas & Hodda (2000) for a detailed study of the nematodes during the latter half of 1999. Despite a year's storage, an abundance of live nematodes were still present in this material which had remained moist in a sealed container.

Invertebrates were collected with a rectangular net (opening 20 x 30 cm, mesh size 150 mm), preserved in 95% ethanol, and sorted under a Wild M7 stereo-microscope. Maximum depth of water was determined with a flexible steel measure. The conductivities of water samples collected in polyethylene bottles were determined with a Radiometer CDM2e conductivity meter.

Results

The maximum depth of water in the rock-hole and the conductivity of the water are plotted in Fig 3. The depth decreased from 74 cm on 26 April to 17 cm on 16 June,1998. The conductivity rose from 114 µS cm^{-1} on 5 May to 993 µS cm^{-1} on 16 June (conductivity for 26 April and 14 May was not determined). Despite the steep rise, the final conductivity was still indicative of fresh water.

The occurrence and periodicity of invertebrate taxa are shown in Table 1. At first sampling, six species were present, three in immature form. Eight larvae of *Aedes (Macleaya)* sp were recorded on this occasion but none were found subsequently. From 5 to 18 May, 1998, there was a stable community consisting of eight species. With the disappearance of large phyllopods, no more than five species occurred during the period 1 to 16 June.

From the mud sample taken on 19 July, 1998, Nicholas & Hodda (2000) obtained not only *Dorylaimus* sp nov (a species present in all net-samples, except for one) but also *Mesodorylaimus rotundolabiatus* and *Heterocephalobus* sp. Both of these last two species are smaller than *Dorylaimus* sp nov and were probably present throughout the life of the pool but not collected because the mesh size

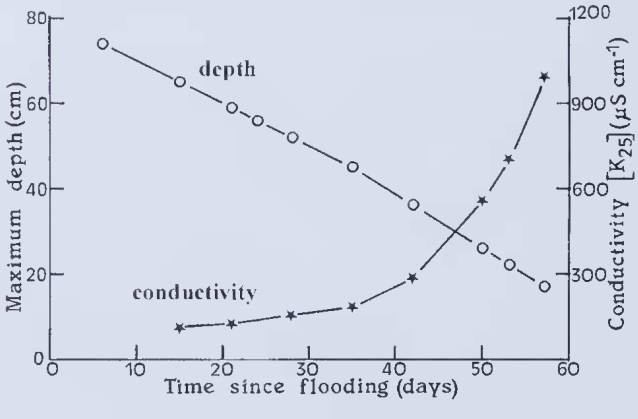

Figure 3. Temporal changes in maximum depth and electrical conductivity of the Warumpi Hill rock-hole.

Table 1. List of taxa collected in 1998 from a rock-hole on Warumpi Hill, Northern Territory, and their period of occurrence (X; or A, adults; I, immature stages) or absence (-).

Sampling date	26 Apr	5 May	11 May	14 May	18 May	25 May	1 Jun	9 Jun	12 Jun	16 Jun
Time since flooding (days)	6	15	21	24	28	35	42	50	53	57
CRUSTACEA: ANOSTRACA										
Streptocephalus sp	I	I	A	A	A	A	-	-	-	-
CRUSTACEA: CONCHOSTRACA										
Lynceus sp	I	A	A	A	A	-	-	-	-	-
CRUSTACEA: NOTOSTRACA										
Triops australiensis Spencer & Hall	I	A	A	A	A	A	-	-	-	-
CRUSTACEA: CLADOCERA										
Moina micrura Kurz	-	X	X	X	X	X	X	X	X	X
CRUSTACEA: OSTRACODA										
Heterocypris aff *tatei*	X	X	X	X	X	X	X	X	X	X
Ilyocypris sp nov	-	X	X	X	X	X	X	X	X	X
INSECTA: DIPTERA										
Aedes (Macleaya) sp	X	-	-	-	-	-	-	-	-	-
Dasyhelea sp	X	X	X	X	X	X	X[a]	-	-	X[a]
NEMATODA: DORYLAIMIDAE										
Dorylaimus sp nov	-	X	X	X	X	X	X	X	X	X

[a] one specimen only.

of the net was too coarse. *Heterocephalobus* was the numerically dominant nematode in the mud sample.

Discussion

The fauna of this central Australian rock-hole differs strikingly in a number of features from that of the granite gnammas studied by Bayly (1982, 1997) in southwestern Australia. Some unexpected species were present, and some expected species were absent.

The occurrence of the anostracan genus *Streptocephalus* in the central Australian rock-hole is surprising. Sars (1896) described the species *S. archeri* from a solitary female raised from a dried mud sample collected near Rockhampton, Queensland. Linder (1941) noted that a further six females, collected from the same locality at a later date, agreed well with Sars's description, but was dubious about the assignment of these seven Rockhampton specimens to *Streptocephalus* in the absence of males. Geddes (1981), in his revision of Australian freshwater Anostraca, treated *Branchinella* as the only genus present. Likewise, Williams (1980) excluded *Streptocephalus* from his taxonomic key to Australian anostracans. For many years, therefore, the consensus has been that the only genus of freshwater fairy shrimp present in Australia was *Branchinella*. However, Sars (1896) stands vindicated; *Streptocephalus* does indeed occur in Australia, a new species from Walkamin, north Queensland, being described by Herbert & Timms (2000). With the present record, this genus is now known from 12 Australian localities, all but three of which are unpublished (B V Timms, University of Newcastle, personal communication). In contrast, *Branchinella longirostris* was the only anostracan found in the southern Western Australian gnammas studied by Bayly (1982,1997).

Adult conchostracans and notostracans were already present only 15 days after flooding. The rapid rate of development of *Triops* ("not more than two weeks") in central Australia was emphasized by Spencer & Hall (1896). Anostracans took somewhat longer to reach maturity. All large branchiopods had disappeared from the water column before six weeks after flooding.

A notable absence was chydorid cladocerans. No fewer than 19 species of Chydoridae, including several with restricted distributions, were recorded by Bayly (1982,1997) from granite gnammas in southern Western Australia. The only cladoceran found at Warumpi Hill, *Moina micrura* (Table 1), is widely distributed (occurring also outside Australia) and was recorded from three Northern Territory localities by Smirnov & Timms (1983).

The ostracod *Heterocypris* occurred in all samples taken from Warumpi Hill (Table 1), but this genus has been found only once in Western Australian rock-holes (Bayly 1997). A new species of *Ilyocypris* was present in all samples except one, but this genus has not been found in Western Australian gnammas.

Culicid mosquito larvae of the subgenus *Aedes (Macleaya)* made a brief appearance shortly after the flooding of the rock-hole. Most species in this taxon are tree-hole breeders, although one widespread species, *A. (M.) tremulus*, has previously been found in rock pools (P S Cranston, CSIRO Entomology Division, personal communication). Ceratopogonid larvae of the genus *Dasyhelea* were abundant in all samples up to and including 25 May, 1998, but thereafter they were rare or absent (Table 1). This genus is common in granite pools in Western Australia (Jones 1971) and in pools on sandstone at two localities near Sydney (Bishop 1974).

A new species of *Dorylaimus* (Nematoda) occurred

in all samples save the first. Nicholas & Hodda (2000) have described this species and commented on the other nematodes recovered from the mud sample. Bishop (1974) recorded *Dorylaimus* from sandstone pools at North Head, Sydney, and Kanangra Walls, Blue Mountains.

A noteworthy feature is the complete absence of copepods crustaceans. In the granite gnammas of southern Western Australia, one of the commonest species is the calanoid copepod, *Boeckella opaqua*. This species is, however, endemic to that State. Cyclopoid copepods were not only absent from the Warumpi Hill rock-hole, but seem generally unimportant in this type of habitat.

Insects were poorly represented in comparison with granite gnammas in Western Australia. Those capable of lengthy flight like dytiscids, corixids and notonectids were all absent. The rock-hole may have been too remote from permanent-water refuges for the presence of these "Group C" animals (see Bayly 1997).

Acknowledgements: I am greatly indebted to the following for taxonomic identifications: B V Timms (Anostraca and Cladocera), P De Deckker (Ostracoda), P S Cranston (Diptera) and W L Nicholas & M E Hodda (Nematoda). I am grateful to C R Twidale for his views on the likely origin of the rock-hole, and R Cass for examining rock samples. Pastor N Wurst of Papunya kindly supplied me with rainfall and temperature data.

References

Bayly I A E 1964 A revision of the Australasian species of the freshwater genera *Boeckella* and *Hemiboeckella* (Copepoda: Calanoida). Australian Journal of Marine and Freshwater Research 15:180-238.

Bayly I A E 1982 Invertebrate fauna and ecology of temporary pools on granite outcrops in southern Western Australia. Australian Journal of Marine and Freshwater Research 33:599-606.

Bayly I A E 1997 Invertebrates of temporary waters in gnammas on granite outcrops in Western Australia. Journal of the Royal Society of Western Australia 80:167-172.

Bayly I A E 1999a Review of how indigenous people managed for water in desert regions of Australia. Journal of the Royal Society of Western Australia 82:17-25.

Bayly I A E 1999b Rock of Ages: Human Use and Natural History of Australian Granites. University of Western Australia Press, Nedlands.

Bishop J A 1974 The fauna of temporary rain pools in eastern New South Wales. Hydrobiologia 44:319-323.

Geddes M C 1981 Revision of Australian species of *Branchinella* (Crustacea: Anostraca). Australian Journal of Marine and Freshwater Research 32:253-295.

Herbert B & Timms B V (2000) A new species of *Streptocephalus (Parastreptocephalus)* (Crustacea: Anostraca: Streptocephalidae) from north Queensland, Australia. Memoirs of the Queensland Museum 45:385-390.

Jones R E 1971 The ecology of some species of Diptera on granite outcrops. PhD Thesis. University of Western Australia, Perth.

Linder F 1941 Contributions to the morphology and taxonomy of the Branchiopoda Anostraca. Zoologiska Bidrag fran Uppsala 20:101-302.

Nicholas W L & Hodda M E 2000 *Dorylaimus baylyi* sp. nov. (Dorylaimidae, Dorylaimida) a new nematode collected from freshwater in a rock-hole in the Northern Territory. Transactions of the Royal Society of South Australia 124(2):163-168.

Sars G O 1896 Description of two new Phyllopoda from north Australia. Archiv for Mathematik og Naturvidenskab, Kristiania 18(8):3-32.

Spencer W B & Hall T S 1896 Crustacea. Report on the Work of the Horn Scientific Expedition to Central Australia 2(Zoology):227-248.

Smirnov N N & Timms B V 1983 A revision of the Australian Cladocera (Crustacea). Records of the Australian Museum, Supplement 1:1-132.

Twidale C R & Corbin E M 1963 Gnammas. Revue de Géomorphologie dynamique 14:1-20.

Williams W D 1980 Australian Freshwater Life. MacMillan, South Melbourne.